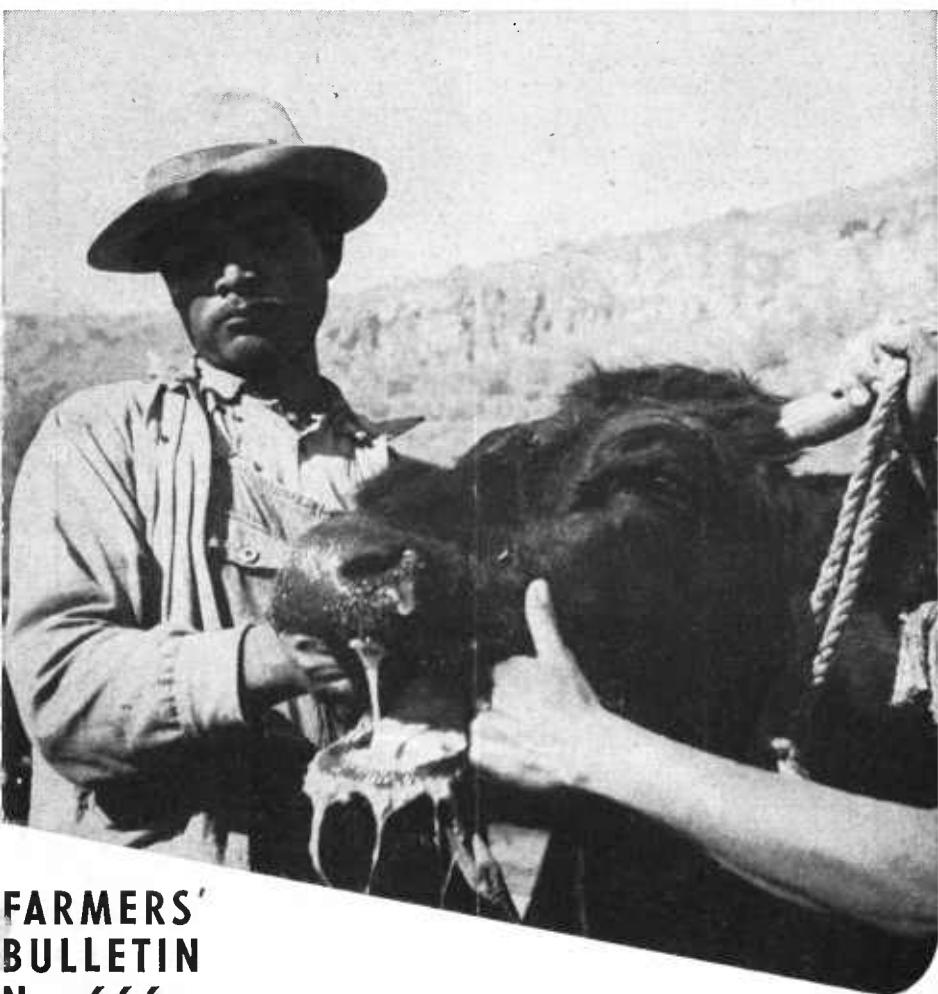


Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

FOOT-AND-MOUTH DISEASE



FARMERS'
BULLETIN
No. 666

U. S. DEPARTMENT OF AGRICULTURE

FOOT-AND-MOUTH DISEASE is one of the most universal diseases of cattle, as well as one of the most difficult to suppress. Although essentially a disease of cattle, most other farm animals are susceptible in varying degrees.

Although not so malignant as some other animal diseases, it nevertheless has been known to cause serious mortality, especially in young animals. Its worst menace, however, consists in its extreme contagiousness, so that when it makes its appearance anywhere it is liable to spread with great rapidity in all directions where there is any movement of livestock. Not only so, but the infection may be carried by persons, dogs, and other nonsusceptible animals, and also by infected hay, straw, or other materials coming in contact with susceptible animals. It is evident, therefore, that only the most prompt and vigorous measures are of any value in eradicating it.

In countries in which the disease has gained a foothold it has become a constant and continuing problem.

The United States has suffered nine foot-and-mouth visitations, ranging in date from 1870 to 1929. Fortunately, after persistent efforts by the Government, the States, local authorities, and individual stockmen, each outbreak was entirely stamped out.

The latest direct threats to the livestock industry of the United States were the outbreaks in Mexico in 1946, and in Canada in 1952.

The following publications reporting various outbreaks are out of print, but may be consulted in libraries:

Nineteenth Annual Report of the Bureau of Animal Industry for 1902; a history of outbreak of 1902-3.

Twenty-fifth Annual Report of the Bureau of Animal Industry for 1908; a history of outbreak of that year.

Bureau of Animal Industry Circular 147, The Origin of the Recent Outbreak of Foot-and-Mouth Disease in the United States (1909).

Department Circular 325, Foot-and-Mouth Disease, with Special Reference to the Outbreaks in California, 1924, and Texas, 1924 and 1925.

Washington, D. C.

Issued April 1915
Revised April 1952

FOOT-AND-MOUTH DISEASE

Prepared by specialists of the Bureau of Animal Industry¹

CONTENTS

	Page		Page
Nature and characteristics of foot-and-mouth disease-----	1	Foot-and-mouth disease in Mexico-----	10
Losses due to foot-and-mouth disease-----	2	Measures for control of the disease in other countries-----	11
Symptoms-----	3	Outbreaks in the United States-----	13
Diagnosis-----	5	Eradication measures used in the United States-----	15
Methods of control and eradication-----	7	Testing cures for the disease-----	19
The disease in other countries---	8	Enforcement of quarantines-----	19

NATURE AND CHARACTERISTICS OF FOOT-AND-MOUTH DISEASE

FOOT-AND-MOUTH DISEASE, also known as apthous fever, aftosa, epizootic aptha, and eczema contagiosa, is an acute, highly communicable disease chiefly confined to cloven-footed animals and characterized by an eruption of vesicles or blisters on the mucous membrane of the mouth and on the skin between the toes and above the hoofs. The vesicles rupture, forming erosions and ulcerations; there are also salivation, tenderness of the affected parts, loss of appetite, lameness, emaciation, and diminution in the quantity of milk secreted.

Although the mortality from the disease is not generally so high as in the case of other infectious animal diseases, in some outbreaks the death rate has been very heavy, especially in young animals. Even when the mortality is low, the damaging effect of the disease on the affected animals is serious; and this, together with its ability to spread rapidly from animal to animal and from one community to another, places foot-and-mouth disease in the front rank of the devastating diseases. The disease has been known for centuries and has existed for long periods in many countries, despite the more or less vigorous methods used for its control.

The tremendous ravages of foot-and-mouth disease are seen in the number and variety of the species attacked. Although it may be regarded as essentially a disease of cattle, hogs seem to be as easy a prey. Almost in the same grade of receptivity are goats and sheep. Other susceptible species include the buffalo, American bison, camel, deer, chamois, llama, giraffe, antelope, and wild swine.

Horses have not been found to be susceptible to the disease. Although dogs, cats, and rabbits have been infected artificially they evidently do not contract the disease under natural conditions. Wild rats, on the other hand, have been found to be susceptible, and there

¹ Revision of former editions by John R. Mohler.

are indications that rats and hedgehogs may acquire infection under natural conditions. Poultry have not been found to be susceptible.

Foot-and-mouth disease is transmissible to man, as has been shown definitely by several accidental laboratory infections and several other well-substantiated cases. Investigators have come to believe, however, that man is not readily susceptible, and consequently the disease does not constitute a public health problem.

It is definitely recognized that foot-and-mouth disease is propagated by a specific virus and that every outbreak starts from some preexisting outbreak.

Experiments have shown that the virus will pass through standard germproof filters; this indicates its minute size and the reason it has not been detected by staining methods. The contagion may be found in the serum of vesicles and vesicle coverings on the mouth, feet, and udder; in the saliva, milk, and various secretions and excretions; also in the blood during the rise of temperature.

A wide distribution of the virus and a rapid infection of a herd are the result. Animals may be infected directly by contact with diseased animals or indirectly from infected manure, hay, utensils, drinking troughs, railway cars, animal markets, barnyards, and pastures. Human beings may carry the virus on their shoes and clothing and even on their hands when milking, since the udder is occasionally the seat of the eruption. It may also be carried by dogs, cats, rats, and other nonsusceptible species. Milk in a raw state may also transmit the disease to animals fed with it.

Infected animals even before they show any visible symptoms of the disease may eliminate virus from their bodies in large quantities, thus acting as an unsuspected source of spread of the disease. Foot-and-mouth disease may attack the same animal several times. Although an attack of the disease produces an immunity that may last for a long time, there are at least three types of virus and while an animal after recovery from the disease produced by one type is immune to that type, it is readily infected with the other types. The period of incubation—that is, the time between exposure of an animal to infection and development of the disease in that animal—is variable, usually from 3 to 6 days. The disease, however, may appear in 24 hours, or in exceptional cases, not for 18 days or even longer.

LOSSES DUE TO FOOT-AND-MOUTH DISEASE

The highly contagious character of foot-and-mouth disease and its rapid spread to practically all exposed, susceptible animals lead to heavy losses.

The mortality from the disease may vary between wide limits. In the mild form of the disease the losses from death may be about 3 percent of the affected animals. However, in the malignant type of the disease the mortality is greatly increased, and in the severe epizootics in Europe between 1918 and 1921, the mortality reached from 30 to 50 percent of the adult animals in some areas.

In addition to the direct loss from deaths of animals, a great loss is also sustained as a result of the animal having had the disease. As the disease progresses the animal, because of the pain and fever, loses weight rapidly, and in lactating animals there is a reduction in milk secretion. The udder often becomes inflamed and in many cases is

ruined by the formation of abscesses. The value of many milking animals is permanently impaired. Inflammation of the feet may in many cases cause considerable difficulty, particularly where secondary infections take place. Some animals are permanently lamed and their value consequently impaired. Abortion is frequent with pregnant animals, and typical lesions have been observed in the newborn. Altogether these losses may amount to from 20 to 30 percent of the value of the affected animals.

There are also indirect losses of a commercial nature. Dairy farmers are put out of business for a time. Necessary quarantine restrictions greatly interfere with the movement of livestock and such commodities as hay, straw, hides, and farm produce. The business of stockyards and slaughtering centers is greatly interfered with. Sometimes it is necessary to close stockyards for disinfection. The whole business of marketing, transporting, feeding, and slaughtering is interrupted and deranged. Losses of this character may reach enormous proportions.

Evidence as to the monetary losses suffered by countries in which foot-and-mouth disease has become established may be gathered from the fact that the estimated direct loss to the livestock industry in Germany during the epizootics of 1920 and 1921 was about \$119,000,000. This sum does not include losses caused by disruption of business caused by quarantine restrictions. Again in Switzerland, for example, the losses in 1920-21 were reported to be about \$70,000,000. The number of susceptible animals in Switzerland at that time was less than one-fiftieth of the number in the United States and the area of that country is less than half that of the State of Maine. The figures give some idea of the losses that the disease would cause in this country if it once became established, particularly in view of our highly specialized animal industries, and the extensive movements of animals from one section of the country to another.

SYMPTOMS

The virus first attacks such tissue as the lining membranes of the mouth, tongue, and digestive tract, as well as tissue between the toes and around the top of the hoof. A vesicle or blister forms at the site of entrance of the virus, which is followed in 24 to 48 hours by a rise in temperature and an invasion of the virus into the blood; the virus is carried to distant parts of the body where it again attacks various tissues, causing blisters to form in the mouth, tongue (fig. 1), lips, and between the toes. The temperature usually drops at this stage of the disease, but the animal shows visible evidence of sickness. There is loss of appetite, a suppression of milk, depression, loss of weight, and lameness, which increases markedly in a few days. The vesicles or blisters soon rupture, discharging a clear or somewhat cloudy fluid. At the site of the vesicles there remains a raw, eroded surface which may have jagged fragments of loose tissue attached to it (fig. 2). These, however, soon disappear after the rupture of the vesicles. In milk cows vesicles may also appear on the teats and udder (fig. 3).

The various lesions are extremely painful to the animal, and in cattle there is usually excessive salivation to such an extent that the

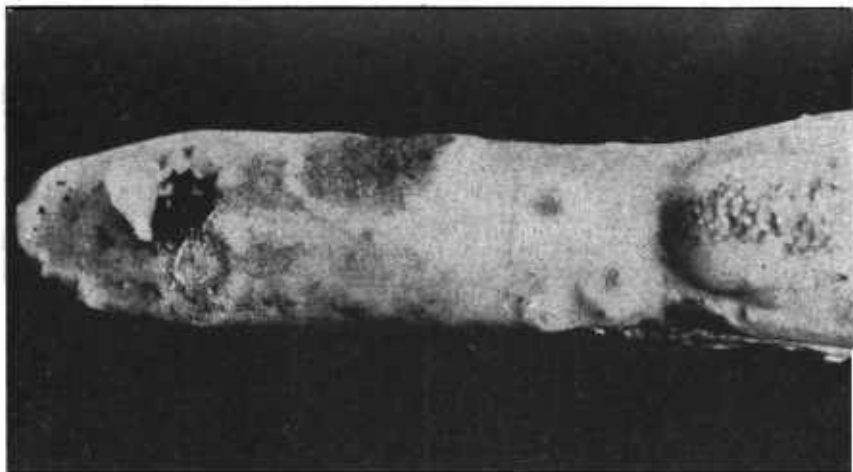
saliva sometimes hangs in strings from the mouth. (See cover page.) Many of the animals make a peculiar smacking sound with the lips. Complications caused by invasion of micro-organisms in the lesions follow in most cases.

The attack upon the feet of an animal is frequently manifested in all four feet at once, but one or more of the feet may entirely escape and remain unaffected throughout the course of the disease. The ulceration of the tissue between the toes may extend to the ligaments of the fetlock or produce disease of the joint or bone. As the feet become sensitive and sore the animal lies down persistently, and it has been found that bedsores develop with amazing rapidity and baffle all attempts at treatment until after the animal has regained its feet.

The disease may attack some of the internal organs before it appears on any of the external tissues. These cases are very likely to prove quickly fatal. The animal dies from paralysis of the heart, due to formation of poisonous substances within the system, or it may suffocate by reason of the action of these same poisons on the tissues of the lungs, or it may choke to death as a result of paralysis of the throat.

In cases of serious affection of the udder, erosions will often be found within the passages of the teats, resulting in a "caked" udder, and the same toxic poisoning which is the cause of death in the apoplectiform types just mentioned may arise from this source. In any event, milk from such cows is dangerous, causing fatal diarrhea in suckling calves or young pigs.

Pregnant animals may abort. In pigs, sheep, and goats the lesions in the foot are most common, but both forms, or only the mouth lesions, may be observed.



79166b

FIGURE 1.—Tongue from a cow that was badly infected with foot-and-mouth disease. The dark areas are vesicles that characterize the disease. The large one on the upper margin is the eroded area left by a broken vesicle, the darker one at the left with a flap is a freshly broken vesicle, and the three light-colored ones at the right are newly formed and about ready to break. The dark area at the extreme right is a broken vesicle.



11992A

FIGURE 2.—Foot-and-mouth lesion on foot. Note the diseased area in the cleft of the foot.

When the disease has become fully established, the duration of the attacks will vary greatly with different animals. From 10 to 20 days are usually required for the recovery of the normal appetite and spirits in mild outbreaks. Milk cows seldom return to a full flow of milk before the following season.

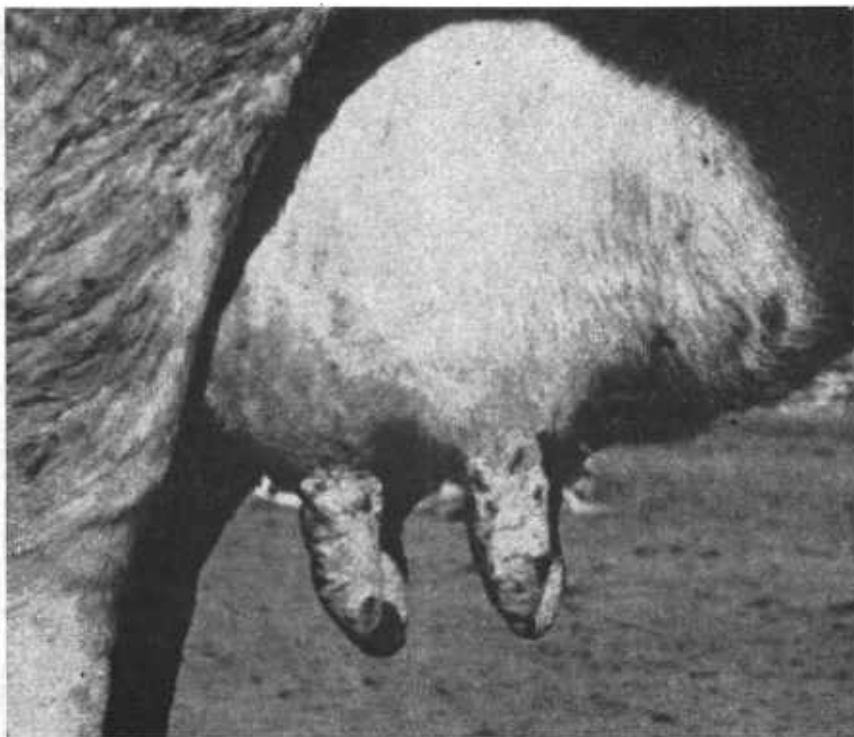
In the malignant type of the disease it requires from 3 months to a year for an animal to recover. The mortality, as already stated, is usually low. Some animals never again return to a normal state of productivity. The disease is more often fatal in young animals that have been fed on infected milk, and produces death in from 60 to 80 percent of these cases as a result of gastroenteritis.

DIAGNOSIS

The diagnosis of foot-and-mouth disease is not, as a rule, difficult when the disease is known to exist in the vicinity. However, the far-

reaching effect of the pronouncement of foot-and-mouth disease in this country makes the initial diagnosis of great importance. The prompt recognition of the disease is likewise of paramount importance in its effective control. This is largely dependent on the vigilance of livestock owners, veterinarians, and others who are charged with the responsibility of reporting promptly any occurrence suspicious of the disease. It is the duty of livestock men to call the attention of State and Federal authorities immediately to animals suspected of having foot-and-mouth disease. The actual diagnosis of the disease when it first makes its appearance should be left to the judgment of designated qualified persons skilled in making observations and tests which distinguish this disease from vesicular stomatitis and other somewhat similar maladies.

The following conditions are grounds for suspecting the presence of the disease: A combination of high fever, vesicular inflammation of the mouth, and hot, painful, swollen condition of the feet. These symptoms, when followed 24 to 48 hours later by the appearance of numerous blisters varying in size from that of a pea to that of a walnut on the udder and feet and in the mouth, should prevent any serious or long-continued error in the diagnosis. When the blisters have ruptured, however, and the resulting lesions have become contaminated by numerous secondary forms of micro-organisms, the correct recognition of the disease may be involved in considerable



79294E

FIGURE 3.—Blisters and scabs of foot-and-mouth disease on teats.

difficulty. Nevertheless in the inoculation of calves and horses there is a certain and final test. In 24 to 96 hours after inoculation the calves present the characteristic blisters, while the horses, in our experience, remain unaffected. Such inoculation, however, should be practiced only by officials who are properly authorized to deal with contagious diseases.

METHODS OF CONTROL AND ERADICATION

The highly infectious nature of the disease, its ease of dissemination, and the ability of the virus to live outside of the body of an animal for long periods must be considered in deciding on measures to prevent spread of the disease. Great care must be taken to keep healthy animals unexposed to the contagion. When an outbreak occurs, the owner should make every effort to keep other animals from coming in contact with his diseased cattle. This especially applies to dogs, cats, goats, and poultry, which usually have access to the stables and barnyards and in this way furnish excellent means for disseminating the infectious principle. He should be equally particular in prohibiting any person from entering his premises, especially an attendant or owner of livestock. Such a herd may be placed under quarantine, with an inspector appointed to keep the premises under constant surveillance.

In the United States, the disease has been combated by the stamping-out, or slaughter method. This consists of the outright slaughter and destruction of affected and exposed animals, rigid quarantine, disinfection of infected premises, and repeated inspections to detect new foci of the disease.

In countries where foot-and-mouth disease has gained a strong foothold as a result of their geographical location without substantial water barriers and their consequent inability to prevent introduction of the disease, the slaughter method alone cannot be employed economically. Such countries are compelled to adopt the next best means, quarantine and vaccination, with or without some slaughter of animals. Many countries of continental Europe and South America must rely on this method in attempting to control the disease.

The slaughter method has for its object the complete eradication of the disease and consists of a rigid quarantine of infected premises, slaughter of all infected and exposed animals in the shortest possible time, and cleaning and disinfection of premises, including all buildings and runs used by infected animals. The disease can be absolutely eradicated by this method, as has been repeatedly shown in the United States.

In a country such as the United States that is free from foot-and-mouth disease and protected from it by geographical situation and quarantine regulations, the slaughter method is the logical one to use when the disease makes its appearance. That this method is the most practical one for wiping out epizootics under the above conditions is recognized by all authorities on foot-and-mouth disease.

The principle of the slaughter method is the prompt eradication of the disease before it can gain any foothold in the country. The success of this method depends on prompt action by the authorities with the full cooperation of the livestock industry and the public at

large. The sooner all animals having the disease are discovered and slaughtered, the more quickly the disease will be eradicated. As the disease is of such a highly infectious nature, it is extremely important that all infected and exposed animals be destroyed and their carcasses buried or burned as quickly as possible so that all sources of infection are eliminated, as the affected animal itself is the chief source of the spread of the disease. This applies particularly to animals in the very early stages of the disease. Vigorous cleaning, disinfection, quarantine, and inspection are also necessary adjuncts to the successful carrying out of the slaughter method. The United States has demonstrated that the disease can be entirely eradicated by the slaughter method at a much less cost than the financial losses would be if the disease were allowed to become well-established.

Fundamental research conducted in Denmark and Germany in 1937-39 produced the first practical vaccine for prevention of foot-and-mouth disease. The vaccine has been used to an increasing extent in almost all countries of Europe and in South America. A similar product has been used as an adjunct to the slaughter method in the joint Mexican-American program. The vaccine has been found to be a practical weapon against the disease where it cannot be eradicated outright by the slaughter method. The vaccine is not infallible, however. The immunity produced is limited both in degree and in length of time it holds. Animals must be vaccinated repeatedly in order to maintain a state of resistance. Moreover, the vaccine must be of the same type as the virus present in the locality.

THE DISEASE IN OTHER COUNTRIES

Foot-and-mouth disease has prevailed in Europe for a great many years and has occasioned tremendous economic losses there.

An outbreak which appeared in Germany in 1888 increased steadily until 1892, when it diminished gradually for a few years, but the disease again reached great proportions in 1899. Thereafter it continued to a greater or lesser extent until in 1911 it attained a virulence previously unequaled, and approximately one out of seven of the susceptible animals was affected. The government attempted to control outbreaks by slaughter of infected herds, but the pestilence had gained too much headway and was too firmly established in various portions of the country for this method to succeed, and it had to be abandoned. In Germany and some other European countries the farmers, realizing that the disease was inevitable made haste to be done with it by exposing their stock deliberately to mild cases in the hope that this would result in an immediate mild attack and immunity for several years thereafter. Such immunity, however, is very uncertain. As soon as an animal's period of acquired immunity is over and favorable conditions present themselves, the contagion breaks out with renewed virulence.

Great Britain, Denmark, Sweden, and Norway, on account of their comparatively isolated positions, have been more successful in keeping out the disease.

Great Britain has applied the combined quarantine and slaughter methods for many years, and sometimes has adopted measures which

were even more stringent than any that have been used in the United States.

For several years prior to 1910 Great Britain was practically free from the disease. Outbreaks occurred in every year from 1910 to 1916, however, and after freedom in 1917 there was a recurrence in 1918. Since that time the disease has been almost constantly present in one part of the United Kingdom or another. The condition became serious in 1923 when there were 1,929 outbreaks in 43 counties and 128,785 animals were slaughtered in efforts at eradication. Also in 1924 there were 1,515 outbreaks and 88,850 animals were slaughtered. Outbreaks continued annually, among the worst being in 1926, 1931, 1937-38, 1940-41, 1942, 1944, and an especially severe one in 1951.

In June 1931 the disease appeared in England in an extremely serious outbreak and threatened to sweep the whole country. Prompt and energetic steps taken by the British Veterinary Service, however, proved effective in limiting the extension of the infection, which had quickly invaded England and Scotland, countries that for several years had enjoyed freedom from the disease. Previous outbreaks in Scotland since 1908 had occurred in 1922, 1923, 1924, and 1926. In the last-mentioned year the disease was apparently found in the carcasses of pigs imported from continental Europe.

In 1922 and 1923 the disease appeared on the Channel Islands, was promptly eradicated, but appeared again in 1938.

Ireland (Northern Ireland and the Irish Free State) experienced visitations only at rare intervals, as in 1928 when there was an outbreak on the southeastern coast of the Irish Free State and in 1931 when the disease appeared in Northern Ireland almost simultaneously with outbreaks in England and Scotland.

The disease has been in Belgium, Czechoslovakia, France, Germany, Netherlands, Italy, Union of Soviet Socialist Republics, Spain, and the Balkan countries. Switzerland in the past has successfully eradicated several outbreaks by the slaughter method.

One of the most serious outbreaks of all time in Europe began in France in 1937, following an importation of sheep from Morocco. Practically every country in Europe suffered heavily from this epizootic which continued through 1938 and into 1939. To complicate the problem, the spread of one type of the virus was followed by another type against which no immunity had developed in animals recovering from the first infection. An example of the extent and seriousness of the 1937-39 epizootic was the occurrence of the disease in more than 50 percent of all herds in Denmark. The disease broke out with renewed fury in 1951 in all Europe including England, and early in 1952 the epizootic was still raging. It was complicated by the appearance of a variant of type A virus against which vaccines in current use gave very little protection.

There is less accurate information regarding Asia and Africa, but while Japan and many islands of the South Pacific are apparently free from the infection, it has been reported from India, Algeria, Tunisia, Morocco, Egypt, the Sudan, Nigeria, Rhodesia, Bechuanaland, and other portions of Africa. In 1933 the disease was introduced into the Union of South Africa from the Bechuanaland Protectorate but was successfully eradicated. In 1937 another outbreak occurred in the Union of South Africa. The disease is known to be prevalent in China, the Philippines, and various islands of the East

Indies. It is doubtful whether any considerable part of the Orient is free from it.

In South America the disease is reported as common in the principal livestock countries—Argentina, Brazil, Paraguay, Uruguay, Venezuela, and Colombia. It appeared in Jamaica in 1922 and spread extensively over the island. It was finally eradicated there in 1927.

Canada had been free from the disease for many years, but it was diagnosed in February 1952 among herds near Regina, Saskatchewan.

Australia and New Zealand have been fortunate in maintaining freedom from the disease for many years.

FOOT-AND-MOUTH DISEASE IN MEXICO

In 1926 there was an outbreak of foot-and-mouth disease in the southeastern part of Mexico, which in December 1927 was officially declared to be eradicated.

Late in 1946, the disease appeared again in Mexico, in the State of Veracruz. According to available evidence, the disease was introduced into Mexico through an importation of Zebu cattle from a South American country. Before effective eradication measures could be taken, it had spread to 16 Mexican States and the Federal District.

Mexican authorities invited the United States Government to assist in controlling and eradicating the disease. A joint Mexican-United States Commission, composed of representatives of each country, was established to plan and direct the program. The plan of operation consisted of diagnosis, quarantine, slaughter of infected and exposed animals, deep burial, cleaning and disinfection of premises, and finally, testing with susceptible animals to insure the completeness of eradication.

Until late November 1947 these methods were used, and slaughter and burial operations had included about half a million cattle together with almost as many swine, sheep, and goats. At that time it was decided that the economy of the country could not withstand a continued loss of so many animals, and a modified program was adopted. The new phase of the program included strengthening the northern and southern quarantine lines between which the infection was confined and provided for vaccination of susceptible healthy animals in the quarantined area. The modified program provided for the elimination of centers of infection by the destruction of actively infected animals.

A laboratory for producing foot-and-mouth disease vaccine was operated in Mexico by the Joint Commission from May 1948 to April 1950. (Fig. 4.) During the vaccination phase of the program, 60,130,189 doses of vaccine were administered to susceptible animals. (Fig. 5.) Laboratory facilities were maintained to test samples submitted by field inspectors from suspected outbreaks.

Importation of animals or fresh meat products likely to carry the infection from Mexico to the United States was prohibited. Other animal products, hay, and straw were permitted entry under restrictive safeguards. Extensive border patrol operations were conducted by the Bureau throughout the campaign to enforce the quarantine.

The latest outbreaks of the disease discovered in Mexico occurred during December 1949, December 1950, and August 1951.

The direct cost to the United States of the Mexican program to date amounts to approximately \$123,000,000. In addition, there were expenses to the Mexican government and to livestock owners.

The joint Mexican-United States campaign to eradicate the disease is continuing.

MEASURES FOR CONTROL OF THE DISEASE IN OTHER COUNTRIES

As already pointed out, in many countries of continental Europe and South America, foot-and-mouth disease has gained a strong foothold. This has been the occasion for much research and special study on methods of dealing with the disease. Germany, Belgium, Switzerland, Sweden, and the Netherlands have provisions in their laws for the slaughter of infected herds with compensation to the owner. These provisions can be put into effect whenever those in control believe that by so doing the extension of the disease can be prevented.

Reliance is placed principally, however, on vaccination, strict isolation, and quarantine, although the slaughter method even in some of those countries is practiced at times, as for example, where an outbreak starts in a new center and where conditions are favorable for stamping out the infection before it can spread.

The regulations of the different countries concerning control measures are nearly all alike since those responsible for the promulgation of these regulations are well acquainted with the facts regarding the



79998B

FIGURE 4.—Inoculating animals in tongue, a step in the production of vaccine.

disease. The application of these rules, however, as well as the vigor with which the regulations are enforced differs in various countries, depending on the extent of the disease, the geographical location, and the economic conditions of the country.

The regulations of the various countries require in general: (1) Mandatory reports of cases of foot-and-mouth disease (or suspected cases) by stock owners, veterinarians, and others to the local police or other authority; (2) quarantine of premises on which infected animals are found; (3) quarantine of a zone surrounding the infected farm; (4) restrictions on the movement of livestock and people in



79975B

FIGURE 5.—Vaccinating a cow against foot-and-mouth disease.

these zones, as well as on cattle products, feed, or other material capable of spreading the infection; (5) vaccination of animals in the areas adjacent to infected farms; (6) periodic disinfection on the infected farms. The quarantines are removed a certain number of days after the recovery or disposal of the last infected animal and after appropriate disinfection of the premises. Infected animals are made as comfortable as possible, and symptomatic and supportive treatment is administered. The use of a hyperimmune or convalescent serum has been used in the treatment of the disease. If it is given early, the severity of the disease may be decreased and the mortality reduced. It has little value when given in the later stages of the disease. The use of the serum, however, is limited since it protects animals from the disease for only a short period, 10 days to 2 weeks, and in some cases it affords little protection. Moreover, as large doses must be used and since the serum is expensive, its use is usually limited to the more valuable animals.

In most countries that are subject to repeated epizootics, government institutes or commercial laboratories have been established for the production of vaccine to be used in control of the disease. Although the vaccine has practical use, it cannot be stored for long intervals and it is valueless unless it is made with the same type of virus as that to be combated in the field. In spite of vaccination procedures, foot-and-mouth disease continues to take heavy toll in many countries.

OUTBREAKS IN THE UNITED STATES

Foot-and-mouth disease has appeared in the United States on several occasions—1870, 1880, 1884, 1902, 1908, 1914, 1924 (twice), and 1929.

The first outbreak in 1870 was introduced by way of Canada, where the infection was brought in by an importation of cattle from Scotland. It spread into the New England States and New York and was arrested within a few months. Its failure to spread more extensively and its early disappearance has been ascribed to favorable conditions, such as the movement of livestock being confined to a West-East direction, the limited trading in animals at that period as compared with that at present, the restriction of traffic by winter weather, and the infrequency of travel.

About 1880 two or three lots of animals affected with the disease were brought to the United States, but the disease was confined to the animals originally affected.

In 1884 there was a small outbreak at Portland, Maine, caused by imported cattle, and the disease spread to a few herds outside of the quarantine station. Owing to the small number of animals affected and the limited area covered by the disease, it was easily brought under control.

In all these early outbreaks the contagion was introduced with imported animals. Since the development of a stringent system of inspection and quarantine of imported livestock no instance of that kind has occurred. On subsequent occasions the infection has evidently been brought in with contaminated products or materials and not by live animals.

Protective measures were strengthened in 1930 by legislation which prohibits the importation of domestic ruminants and swine and of their fresh meats originating in any country where foot-and-mouth disease exists.

In November 1902 the disease was discovered in Massachusetts and Rhode Island. The earliest cases were traced to Chelsea, Mass., near the docks, and it was suspected for a time that the infection was brought in with foreign shipping, by some such means as hay, straw, halters; ropes, hides, hair, wool, etc.

This outbreak involved Massachusetts, New Hampshire, Vermont, and Rhode Island. It was eradicated in about 6 months.

The next appearance of foot-and-mouth disease was early in November 1908, when it was observed in cattle near Danville, Pa. A Federal quarantine was issued November 12. The infection was traced back to the stockyards at East Buffalo, N. Y., and to Detroit, Mich. The disease appeared in Michigan, New York, Pennsylvania, and Maryland. A careful and thorough investigation demonstrated that the outbreak started from calves used to propagate vaccinia at an establishment near Detroit, and that the source of the infection was contaminated Japanese smallpox vaccine.

Vigorous measures of eradication similar to those employed in 1902-3 were at once put into effect and the disease was stamped out in about 5 months.

Another outbreak was discovered in the vicinity of Niles, Mich., in October 1914, after it had been under way since August of that year. A campaign to check the spread of the disease and to stamp it out was immediately begun by the United States Department of Agriculture in cooperation with State authorities. The first Federal quarantine was issued October 19, 1914. The outbreak turned out to be the most serious and extensive ever known in this country, the last infection not being disposed of until May 1916. It spread into 22 States and the District of Columbia. The affected States were New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Ohio, Michigan, Indiana, Kentucky, Wisconsin, Illinois, Minnesota, Iowa, Kansas, Montana, and Washington. The Middle Western and Eastern States were mostly affected. More than one-third of the total losses occurred in Illinois. The Union Stock Yards at Chicago became infected early and were a source of dissemination of the contagion in all directions. These yards and others found infected were closed temporarily and disinfected. The methods of eradication, in general, were the same as in the two preceding outbreaks, namely, quarantine, inspection, slaughter of diseased and exposed animals, and disinfection of premises.

In round figures the total number of animals slaughtered in the outbreak was 172,000, comprising 77,000 cattle, 85,000 swine, 10,000 sheep, 114 goats, and 9 deer. The appraised value of these animals was approximately \$5,860,000, half of the expense being borne by the Federal Government and half by the States involved. Other expenses brought the total Government expenditures to about \$4,600,000. Adding the quotas expended by the States, the entire cost of eradicating the outbreak amounted to about \$9,000,000.

In February 1924 foot-and-mouth disease was discovered in two herds of dairy cattle near Oakland, Calif. The source of the infec-

tion was unknown, but it is believed to be the Orient, as the disease was traced to hogs fed on garbage from ships. Eradication was promptly undertaken by Federal and State forces by methods followed in previous outbreaks. Some unusual difficulties were encountered in the spread of the disease to large range herds and flocks in rough, inaccessible, poorly-fenced country and to deer in a national forest. The disease extended to 16 counties in California, and was eradicated in 10 months. There was some recurrence of the disease, however, during the next year, and the last cases were disposed of by June 10, 1925.

Before the California outbreak had been suppressed the disease also appeared in Texas late in September 1924, in a herd of Zebu (Brahman) cattle south of Houston. Investigation showed that the infection probably entered through a port on the Gulf of Mexico. The Texas outbreak, affecting two counties, was apparently suppressed within 30 days by the usual vigorous measures, but nearly a year later, in July 1925, the disease reappeared on the same premises where it had first been found. Eradication was completed in October.

The animals slaughtered in eradicating the California and Texas outbreaks were as follows: In California, 58,791 cattle, 28,382 sheep, 21,195 swine, 1,391 goats, and 22,214 deer, making a total of 131,973 animals. In Texas, 29,323 cattle, 1,429 sheep, 821 swine, and 345 goats; total, 31,918 animals. The appraised value of animals and property destroyed was more than \$5,000,000.

Another outbreak² occurred in southern California in 1929, under much the same conditions as the preceding one. A positive diagnosis of foot-and-mouth disease was reported on January 18 from a large herd of garbage-fed swine near Whittier, in Los Angeles County. The source of the infection was traced to garbage from a trading steamship which had recently docked at San Pedro after being supplied with fresh meat at a South American port. Federal and State quarantines were at once put into effect and the herd of swine was slaughtered and buried on January 19.

On January 30 the infection broke out in a herd of cattle about 8 miles distant from the original outbreak, and 3 days later another herd of cattle in the same vicinity as the second one was found to be affected. Rigorous search disclosed no further infection until on February 6 the disease again appeared 6½ miles to the south, and 10 days later the infection was found on another farm a few miles away. The 1929 outbreak was confined to the five premises mentioned, but 28 additional contact herds were also destroyed as a precautionary measure. Quarantine was removed from the affected area on March 18.

ERADICATION MEASURES USED IN THE UNITED STATES

The slaughter method of eradication, used in the United States, includes the following points: Quarantine of premises where the outbreak occurs; disposal of infected and exposed animals by slaughter and burial or burning; cleaning and disinfection of premises and all equipment; and testing the infectivity of the premises by restocking with susceptible animals.

² An unusual disease in swine, resembling foot-and-mouth disease and tentatively diagnosed as such, occurred in southern California in 1932. Subsequent developments, however, showed the malady to be vesicular exanthema.

This work is actively undertaken by the Bureau of Animal Industry, United States Department of Agriculture, in cooperation with officials of the States in which the outbreak occurs. The expense of eradication has been shared by the Federal Government and the State.

Because of the highly contagious character of the disease, strict quarantine regulations are put into effect as soon as foot-and-mouth disease is suspected. These restrictions are removed only when the disease has been determined to be other than foot-and-mouth disease or when there is reason to believe that the outbreak has been eradicated and that the virus no longer exists on the premises or in the locality.

The necessity for effective quarantine measures is evident from the following facts: (1) Foot-and-mouth disease is most actively contagious in the early stage; (2) practically all cloven-footed animals are highly susceptible, and the greatest source of danger is removed by slaughter and proper disposal of the involved animals; (3) the virus of the disease may be carried by persons, dogs, rabbits, etc., and by any object that may become contaminated with active virus; and (4) there are conditions which may exist in the field under which the virus may remain active for 1 or 2 months and even longer. Cleaning and disinfection after the slaughter of infected animals are designed to remove the virus, but in spite of these precautions there is the possibility of some infection remaining. Hence assurance of complete removal of every vestige of infectious material cannot be given until test animals, introduced onto the premises, are found to remain healthy. Further restocking may then take place gradually but, as a safeguard, inspections are made at regular intervals.

Until the disease has been brought under control, restrictions are placed on the movement of animals, animal byproducts, feed, and other materials which may carry the contagion. Unauthorized persons are forbidden access to quarantined premises, and the movements of employees and other persons from quarantined premises are supervised. Promiscuous visiting of people in an area where the disease exists is discouraged because, next to infected animals, human beings are considered to be the most important factors in the spread of the disease. The close contact that farmers have with stock and the fact that the virus can be carried by persons, on their hands or clothing, emphasizes the importance of strict quarantine measures to check the spread of the disease.

Disposal of Infected and Exposed Animals by Slaughter and Burial

The object of the slaughter method is to remove, as soon as possible, the greatest source of active virus. Even though the disease spreads rapidly, involving practically all cloven-footed animals, it frequently takes from 1 to several weeks before all susceptible animals in a herd have contracted the disease and in turn have passed through the highly infectious stage. During this entire period each animal or group of animals becomes a source of danger, in many instances even before any evidence of the disease is seen.

The fluid and coverings of the vesicles contain the infective agent in concentrated form. Also, animals may discharge the virus in

large quantities even before fever or other indication of the disease appears. Therefore, all animals should be slaughtered and buried in a group as soon as possible after the presence of foot-and-mouth disease has become established in a herd. Since the disease spreads rapidly, it is necessary to destroy not only affected animals but also those that have been exposed to the infection. The carcasses of both infected and exposed animals should be totally destroyed by cremation or by burying in a trench at least 6 feet deep and covering them with air-slacked lime before they are covered with earth. (Fig. 6.)

The slaughter method also disposes of possible carriers of the virus such as animals that might otherwise recover from the disease and carry or spread the infection to other animals.

Cleaning and Disinfection

The object of cleaning and disinfection is the destruction of the virus on infected premises. These procedures should be carried out



79646B

FIGURE 6.—Method of slaughtering and burying cattle. The trench is deep enough to allow carcasses to be covered with at least 5 feet of dirt. Animals are led into the trench and there killed, usually by shooting.

in a very thorough manner. While in some instances the virus dies rather quickly outside the animal body, under certain conditions it may remain alive for considerable periods and be capable of producing the infection. This applies particularly to fragments of freshly ruptured vesicles, which are especially rich in virus. When this material finds favorable conditions the virus may remain active for several months.

In general the virus of foot-and-mouth disease can resist the influence of cold more readily than that of heat. It is quickly destroyed by heat. For example, 140° F. (60° C.) will destroy the virus in from 5 to 30 minutes.

Care should be exercised in selecting suitable disinfectants. Sodium hydroxide in the form of commercial caustic soda or lye is the most suitable for general disinfection. The caustic soda or lye should contain at least 90 percent of actual sodium hydroxide. The disinfecting solution is prepared by dissolving 2 pounds of lye in 10 gallons of water. If hydrated or water slaked (*not air-slaked*) lime is available, a satisfactory disinfecting solution may be prepared by dissolving 1 pound of lye in 10 gallons of water and adding to this 5 pounds of lime. The addition of lime to a solution of sodium hydroxide tends to prevent conversion of the hydroxide to carbonate. The lime is also useful as an indicator to show where the solution has been applied.

Concentrated lye is a caustic poison. Care should be taken to avoid getting it into the eyes or breathing any of the fine dust that may arise where the dry material is handled. The comparatively weak solution employed for disinfection may be used with safety provided a reasonable degree of care is exercised. Washing with water will usually be sufficient to remove the lye solution should any get on the skin. If necessary, it may be neutralized by washing with vinegar. Should any of the lye solution get in the eyes, they may be washed with clean water, to be followed by a saturated water solution of boric acid.

The dilute lye solution has little or no harmful effect on bare wood, rubber, or cotton. It is injurious to painted or varnished surfaces and to woolen or silk fabrics if allowed to remain in contact with them for a considerable period of time. Leather, especially when oiled, will stand some exposure, but it is better to avoid unnecessary exposure. Lye solution may be kept in containers made of bare wood, earthenware, enamelware, or any of the common metals except aluminum. The containers should be kept tightly covered to prevent the conversion of hydroxide into carbonate, which is much less active than the hydroxide. Further information is given in Farmers' Bulletin 1991, *The Use of Disinfectants on the Farm*.

When caustic soda is unavailable or cannot be used because of its corrosive properties, some other disinfectant may be employed. Sodium carbonate, commonly referred to as washing soda, is considerably less caustic and irritating than lye and may be used in a 4-percent solution. It is more rapidly effective if the solution is hot or at least warm.

Three other disinfectants have been used in past outbreaks and have given good service under certain conditions. These are formalin (40 percent solution of formaldehyde) used in a 3-percent solution; saponated cresol solution, U. S. P., in a 3-percent solution (or a similar

product, cresylic disinfectant, in the same strength) ; and chloride of lime, U. S. P. (30 percent of available chlorine), in the proportion of 1 pound to 3 gallons of water.

It is of extreme importance that thorough cleaning be undertaken before disinfection is begun. Cracks or crevices are thoroughly cleaned, and old boards, manure, and materials that interfere with proper cleaning are removed and disposed of in the manner prescribed.

Testing Infectivity of Premises and Restocking

In order to determine that premises, after slaughter of infected and exposed animals and other cleaning and disinfection, are free from the virus, the premises are tested by officials who place a few animals on them after 30 days from the date of completion of disinfection. Such restocking, however, is practicable only if no active infection is present in the locality. Frequent inspection of these animals is made, and if they remain healthy, further restocking may be conducted gradually. As a further safeguard, inspections of new stock are made at regular intervals.

TESTING CURES FOR THE DISEASE

The Bureau of Animal Industry receives many suggestions for curing or otherwise treating animals with foot-and-mouth disease. Treatments cannot be depended upon to stop the spread of the disease to other animals. Resorting to remedies or cures presupposes the continued existence of the disease, whereas in the United States the desired goal is prompt and complete eradication. At best, cures and remedies only alleviate symptoms and in the long run make eradication even more difficult.

Requests that the Bureau test remedies in its laboratories cannot be fulfilled in this country at the present time. Such procedure would necessitate bringing the disease within the continental limits of the United States for study, which is prohibited by law and not within the Bureau's authority.

ENFORCEMENT OF QUARANTINES

Animal quarantine legislation directs the Secretary of Agriculture to take action designed to exclude dangerous livestock infections from the United States. Under this authority he prescribes conditions under which animals and products may be permitted entry, or are destroyed if entered illegally into the United States. The Tariff Act of 1930 prohibits the importation of cattle, sheep, or other domestic ruminants or swine, or of fresh, chilled or frozen meat of such animals, from a country in which foot-and-mouth disease is known to exist. The Federal and State veterinary agencies are charged with the main responsibility for meeting the menace of this disease.

A motion picture, **OUTBREAK** (16 mm., sound, color, 29 minutes, released 1949) tells how foot-and-mouth disease has menaced the livestock of the world for many years and how the outbreaks in the United States and Mexico have been handled. A list of State cooperating film libraries from which the film may be obtained is available from the U. S. Department of Agriculture, Washington 25, D. C.

30941